



US008932379B2

(12) **United States Patent**  
**Ikeda et al.**

(10) **Patent No.:** **US 8,932,379 B2**  
(45) **Date of Patent:** **Jan. 13, 2015**

(54) **EXHAUST GAS PURIFICATION SYSTEM**

(75) Inventors: **Takashi Ikeda**, Fujisawa (JP); **Takayuki Mukunashi**, Fujisawa (JP); **Hiroyuki Ishikawa**, Fujisawa (JP)

(73) Assignee: **Isuzu Motors Limited**, Tokyo (JP)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 87 days.

(21) Appl. No.: **13/703,259**

(22) PCT Filed: **Jun. 10, 2011**

(86) PCT No.: **PCT/JP2011/063323**

§ 371 (c)(1),  
(2), (4) Date: **Dec. 10, 2012**

(87) PCT Pub. No.: **WO2011/155588**

PCT Pub. Date: **Dec. 15, 2011**

(65) **Prior Publication Data**

US 2013/0081366 A1 Apr. 4, 2013

(30) **Foreign Application Priority Data**

Jun. 11, 2010 (JP) ..... 2010-134514

(51) **Int. Cl.**  
**B01D 50/00** (2006.01)  
**B01D 24/00** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **B01D 46/0063** (2013.01); **F01N 3/0253** (2013.01); **F02B 37/24** (2013.01); **F02D 41/0005** (2013.01); **F02D 41/0007** (2013.01); **F02D 41/0055** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... F01N 9/002; F01B 37/24; F02D 41/0055; F02D 41/029; Y02T 10/40; Y02T 10/47  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,829,890 B2 \* 12/2004 Gui et al. .... 60/295  
6,931,842 B2 \* 8/2005 Ohtake et al. .... 60/295

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2004-44524 2/2004  
JP 2004-68804 3/2004

(Continued)

OTHER PUBLICATIONS

International Search Report of Corresponding PCT Application PCT/JP2011/063323 mailed Sep. 13, 2011.

(Continued)

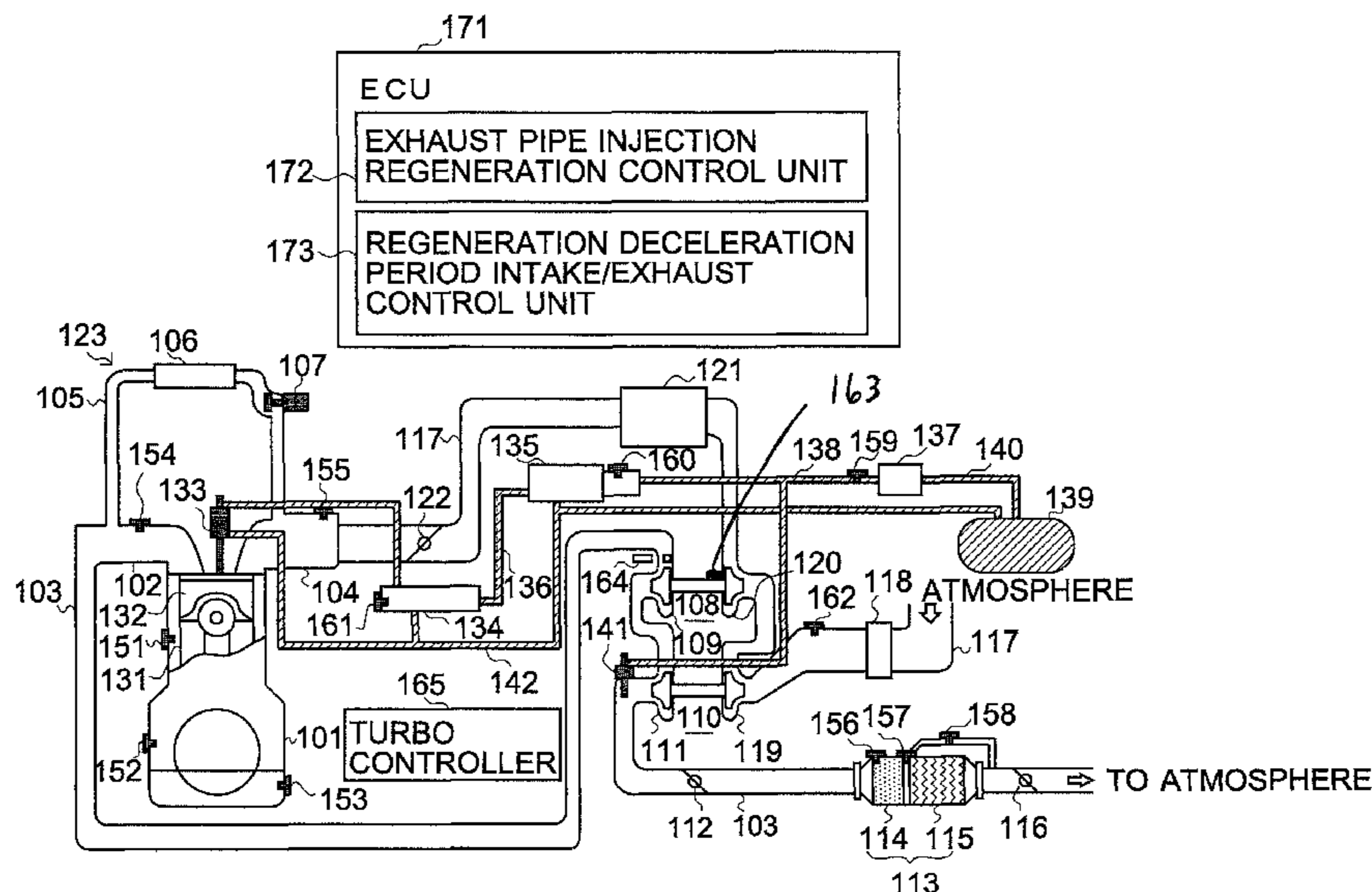
*Primary Examiner* — Amber Orlando

(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(57) **ABSTRACT**

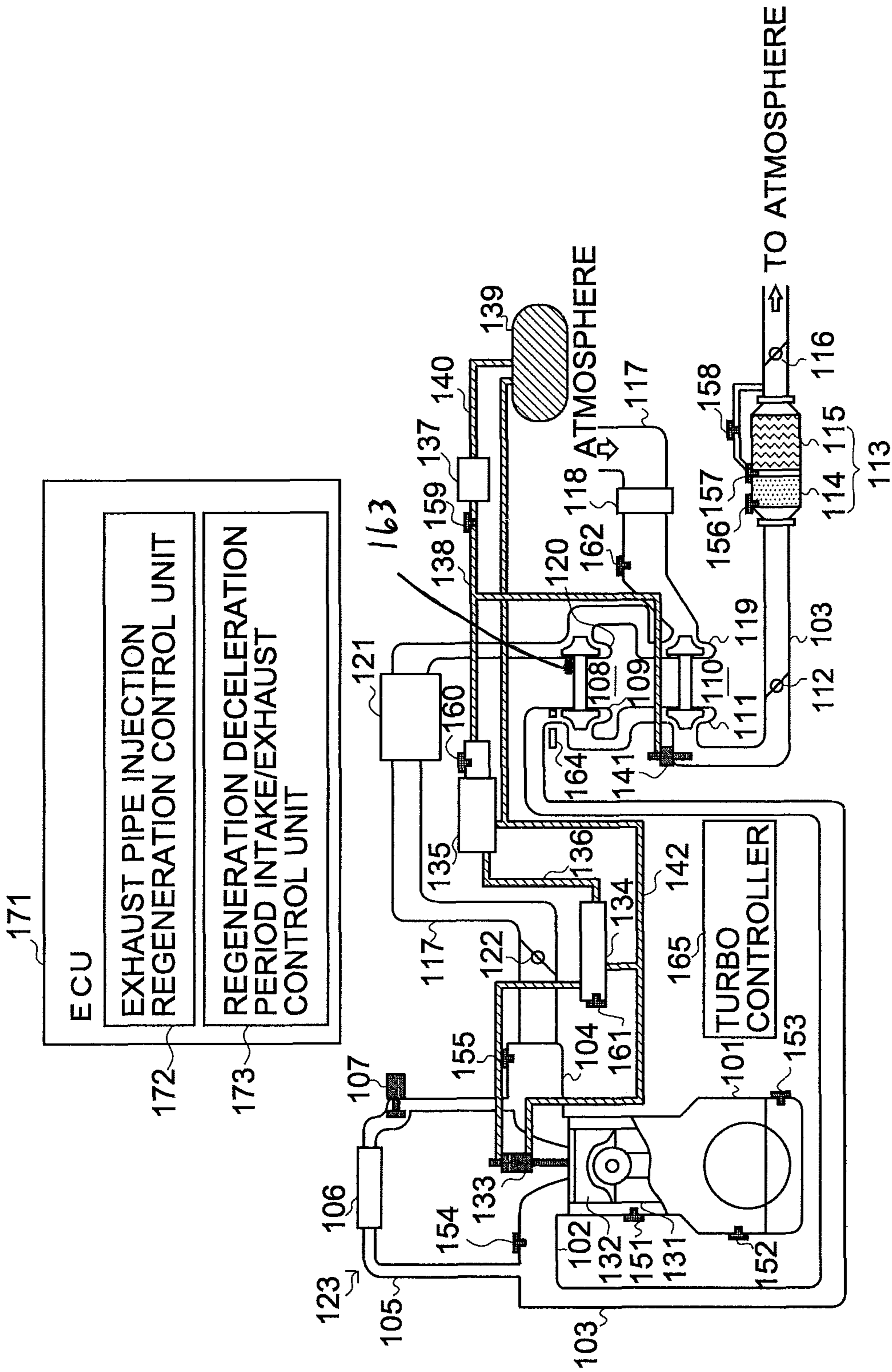
An exhaust gas purification system with which diesel particulate filter (“DPF”) regeneration can be continued even when deceleration occurs during the DPF regeneration. The system includes a regeneration deceleration period intake/exhaust control unit that, when a vehicle decelerates during the DPF regeneration, increases an exhaust gas flow rate through an exhaust pipe by controlling respective openings of an exhaust gas recirculation (“EGR”) device and an intake throttle and adjusting a turbocharging amount of a high pressure stage turbocharger.

**16 Claims, 1 Drawing Sheet**



- (51) **Int. Cl.**  
*B01D 39/14* (2006.01)  
*B01D 39/06* (2006.01)  
*B01D 39/20* (2006.01)  
*B01D 46/00* (2006.01)  
*F01N 3/025* (2006.01)  
*F02B 37/24* (2006.01)  
*F02D 41/00* (2006.01)  
*F02D 41/02* (2006.01)  
*F02M 25/07* (2006.01)  
*F01N 9/00* (2006.01)  
*F02B 37/013* (2006.01)  
*B01D 46/42* (2006.01)  
*F01N 13/00* (2010.01)  
*F01N 3/10* (2006.01)
- (52) **U.S. Cl.**  
 CPC ..... *F02D 41/029* (2013.01); *F02M 25/0711*  
 (2013.01); *F02M 25/0718* (2013.01); *F01N*  
*9/002* (2013.01); *F02B 37/013* (2013.01);  
*B01D 46/42* (2013.01); *F01N 13/0097*  
 (2013.01); *F02D 2041/0017* (2013.01); *F02D*  
*2041/0022* (2013.01); *Y02T 10/144* (2013.01);  
*Y02T 10/42* (2013.01); *Y02T 10/47* (2013.01);  
*F01N 3/103* (2013.01); *B01D 2279/30*  
 (2013.01)  
 USPC ..... **55/282.3**; 55/522; 55/523; 55/524;  
 422/169; 422/170; 422/171; 422/172; 422/177;  
 422/178; 422/179; 422/180; 422/181; 422/182

- (56) **References Cited**
- U.S. PATENT DOCUMENTS
- |              |      |         |               |        |
|--------------|------|---------|---------------|--------|
| 8,037,675    | B2 * | 10/2011 | Tahara et al. | 60/286 |
| 2004/0031262 | A1 * | 2/2004  | Gui et al.    | 60/285 |
| 2004/0103654 | A1 * | 6/2004  | Ohtake et al. | 60/295 |
| 2007/0266701 | A1 * | 11/2007 | Cheng         | 60/295 |
| 2008/0006024 | A1 * | 1/2008  | Tahara et al. | 60/274 |
| 2008/0209887 | A1 * | 9/2008  | Hanari et al. | 60/277 |
- FOREIGN PATENT DOCUMENTS
- |    |             |        |
|----|-------------|--------|
| JP | 2004-190668 | 7/2004 |
| JP | 2006-189024 | 7/2006 |
| JP | 2009-167906 | 7/2009 |
| JP | 2010-106691 | 5/2010 |
- OTHER PUBLICATIONS
- Patent Abstracts of Japan, Publication No. 2004-068804, Published Mar. 4, 2004.  
 Patent Abstracts of Japan, Publication No. 2004-044524, Published Feb. 12, 2004.  
 Patent Abstracts of Japan, Publication No. 2006-189024, Published Jul. 20, 2006.  
 Patent Abstracts of Japan, Publication No. 2004-190668, Published Jul. 8, 2004.  
 Patent Abstracts of Japan, Publication No. 2010-106691, Published May 13, 2010.  
 Patent Abstracts of Japan, Publication No. 2009-167906, Published Jul. 30, 2009.  
 Written Opinion of the International Searching Authority mailed Sep. 13, 2011 in corresponding International Application No. PCT/JP2011/063323.
- \* cited by examiner





**EXHAUST GAS PURIFICATION SYSTEM****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit of Japanese Patent Application No. 2010-134514, filed on Jun. 11, 2010, the contents of which is incorporated herein by reference, which serves as priority for PCT Application No. PCT/JP2011/063323, filed Jun. 10, 2011.

**TECHNICAL FIELD**

The present invention relates to an exhaust gas purification system that injects fuel for diesel particulate filter ("DPF") regeneration, and more particularly to an exhaust gas purification system with which DPF regeneration can be continued even when deceleration occurs during the DPF regeneration.

**BACKGROUND**

A DPF is provided in an exhaust pipe in order to purify exhaust gas from a diesel engine by removing particulate matter (to be referred to hereafter as PM) from the exhaust gas. The DPF collects the PM in a honeycomb structure formed from a porous ceramic. When the collected PM accumulates excessively, circulation of the exhaust gas is impaired, but by increasing an exhaust gas temperature, the PM collected in the DPF can be incinerated and removed. This operation is known as DPF regeneration.

In a conventional method for increasing the exhaust gas temperature to a temperature at which the PM can be incinerated, an oxidation catalyst (to be referred to hereafter as a DOC) constituted by platinum or the like is disposed upstream of the DPF, and the exhaust gas temperature is raised to an activation temperature of the DOC by increasing a fuel injection amount of a multi-injection, in which fuel injection is performed a plurality of times to obtain propulsive force in the engine. Next, a DPF regeneration fuel injection (a post injection) is performed at an appropriate crank angle such that hydrocarbon (to be referred to hereafter as HC) is supplied to the DOC by the post injection, and the exhaust gas temperature is raised by oxidation heat from the HC. When the post injection is performed, however, oil dilution, in which the injected fuel intermixes with lubricating oil of the engine and thereby diluted, occurs. Further, when unburned fuel from the post injection intermixes with exhaust gas recirculation (to be referred to as EGR hereafter), a performance of an EGR cooler deteriorates and a defect occurs in a piston ring.

Hence, in recent years, a method of supplying HC to the DOC by providing a new device in the exhaust pipe and performing an exhaust pipe injection to inject fuel into the exhaust pipe such that the exhaust gas temperature is raised by the oxidation heat of the HC has been investigated.

**PRIOR ART DOCUMENT****PRIOR ART DOCUMENT****Patent Documents**

Patent Document 1: Japanese Patent Application Publication No. 2010-106691

**SUMMARY OF THE INVENTION**

In the exhaust pipe injection, in contrast to the post injection in which fuel is injected into a cylinder, an injection

timing is determined irrespective of the crank angle, and a fuel injection amount is also determined arbitrarily. However, exhaust pipe injection technology is new, and therefore a large amount of time must be expended on experiments for determining an injection timing and a fuel injection amount at which the exhaust gas temperature can be raised effectively and without wasting fuel. Post injection technology, on the other hand, has already been established through many experiments, and therefore appropriate injection timings and injection fuel amounts have been mapped. Hence, the present inventors considered setting a target injection amount of a fuel injection amount for an exhaust pipe injection on the basis a target injection amount for a post injection. A target injection amount map for the exhaust pipe injection was set such that an amount of fuel corresponding to a fuel injection amount post-injected into each cylinder during a single combustion cycle of the engine is injected in the exhaust pipe injection within a predetermined time corresponding to a single combustion cycle. By converting the established injection timing and target injection amount of the post injection for use during the exhaust pipe injection in this manner rather than starting from a so-called zero base, the amount of time expended on experiments can be shortened.

Incidentally, post injections are conventionally prohibited during vehicle deceleration in which an accelerator pedal is released (not depressed), or in other words engine braking. The reason for this is that during engine braking, the amount of fuel injected in the multi-injection is small, and therefore the exhaust gas temperature decreases such that the DOC is cooled by the exhaust gas. Accordingly, the temperature of the DOC falls below the activation temperature, and as a result, the post-injected fuel is not oxidized by the DOC but discharged from the exhaust pipe as white smoke. Hence, when an engine brake is activated during DPF regeneration, the DPF regeneration must be interrupted.

In response to this problem, the present inventors proposed a temperature maintaining mode in which the DPF and the DOC are held at high temperatures during engine braking. In the temperature maintaining mode, a fresh air intake is reduced by reducing an opening of an intake throttle, and at the same time, an amount of exhaust gas flowing into the exhaust pipe is reduced by increasing an opening of an EGR device such that a larger amount of exhaust gas is recirculated to the engine. As a result, the temperatures of the DPF and the DOC do not decrease from the high temperatures thereof prior to the start of engine braking. Thus, the DOC can be maintained at the activation temperature for a fixed amount of time. Further, the DPF is held at the PM incineration temperature, and therefore a rapid reduction in a regeneration temperature can be prevented during engine braking.

However, when the exhaust pipe injection is performed while the temperature maintaining mode is set, the regeneration temperature increases due to the lack of fresh air, and as a result, the DPF and an SCR device provided downstream thereof may suffer melt damage. A possible cause of an increase in the temperatures of the DPF and the DOC is that the amount of exhaust gas flowing into the exhaust pipe is small and therefore the exhaust gas is retained in the exhaust pipe, while the injected fuel does not flow toward the DOC and is therefore ignited in the exhaust pipe. Further, in a case where control is performed to detect an inlet temperature of the DPF and increase the exhaust pipe injection amount until the DPF reaches the regeneration temperature, since the exhaust gas does not flow, an amount of time required for the injected fuel to reach the DOC increases, and therefore the inlet temperature of the DPF increases at a response delay



relative to the fuel injection. Accordingly, the exhaust pipe injection amount increases dramatically, and as a result, ignition occurs.

It is therefore an object of the present invention to solve the problems described above by providing an exhaust gas purification system with which DPF regeneration can be continued even when deceleration occurs during the DPF regeneration.

To achieve the object described above, the present invention provides an exhaust gas purification system including: a diesel particulate filter disposed in an exhaust pipe of an engine to collect particulate matter; an exhaust gas recirculation device that recirculates exhaust gas from an exhaust manifold to an intake manifold of the engine in accordance with an instructed exhaust gas recirculation opening; a variable nozzle turbocharger which performs turbocharging when a turbine disposed in the exhaust pipe and a compressor disposed in an intake pipe of the engine rotate integrally, a turbocharging amount of which can be adjusted using an actuator; an intake throttle disposed between the turbocharger and the intake manifold to limit an intake air amount in accordance with an instructed intake throttle opening; and a regeneration deceleration period intake/exhaust control unit that, when a vehicle decelerates during regeneration of the diesel particulate filter, increases an exhaust gas flow rate through the exhaust pipe by controlling the opening of the exhaust gas recirculation device and the opening of the intake throttle and adjusting the turbocharging amount of the variable nozzle turbocharger.

When the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit may fully close the opening of the exhaust gas recirculation device.

When the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit may fully open the opening of the intake throttle.

When the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit may increase the turbocharging amount of the variable nozzle turbocharger.

The exhaust gas purification system may further include: an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

The present invention exhibits the following favorable effect.

DPF regeneration can be continued even when deceleration occurs during DPF regeneration.

#### BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a system diagram showing configurations of an engine, an intake/exhaust system, and a fuel injection system of a vehicle to which an exhaust gas purification system according to the present invention is applied.

#### DETAILED DESCRIPTION

Embodiments of the present invention will be described in detail below on the basis of the attached drawings.

FIG. 1 shows system configurations of an engine, an intake/exhaust system, and a fuel injection system of a vehicle to which an exhaust gas purification system according to the present invention is applied.

First, the configuration of the exhaust system will be described. An exhaust pipe **103** for discharging exhaust gas from an engine **101** into the atmosphere is connected to an exhaust manifold **102** of the engine **101**, and an EGR pipe **105** for circulating the exhaust gas from the exhaust manifold **102** to an intake manifold **104** is provided on a furthest upstream side of the exhaust pipe **103**. An EGR cooler **106** that cools the exhaust gas and an EGR valve **107** for regulating an EGR amount (or an EGR rate) are provided in the EGR pipe **105**. The EGR pipe **105**, the EGR cooler **106**, and the EGR valve **107** will be referred to collectively as an EGR device **123**. The EGR device **123** circulates the exhaust gas from the exhaust manifold **102** to the intake manifold **104** in accordance with an instructed EGR opening.

A turbine **109** of a high pressure stage turbocharger **108** is provided on a downstream side of the exhaust pipe **103**, and a turbine **111** of a low pressure stage turbocharger **110** is provided downstream thereof. An exhaust brake valve **112** that closes the exhaust pipe **103** is provided downstream of the turbine **111**, and a DPF unit **113** is provided downstream thereof. The DPF unit **113** is constituted by a DOC **114** that advances the oxidation of fuel injected into the exhaust pipe **103** during DPF regeneration, and a DPF **115** that collects PM. An exhaust throttle **116** may be provided downstream of the DPF unit **113**, and downstream of the exhaust throttle **116**, the exhaust pipe **103** is open to the atmosphere. Although not shown in the drawing, an SCR (Selective Catalytic Reduction) device may be provided in the exhaust pipe **103**.

Next, the configuration of the intake system will be described. An intake pipe **117** for taking air into the engine **101** from the atmosphere is connected to the intake manifold **104**. A furthest upstream side of the intake pipe **117** is open to the atmosphere, and an air cleaner **118** that removes foreign matter such as dust is provided downstream thereof. A compressor **119** of the low pressure stage turbocharger **110** is provided downstream of the air cleaner **118**, and a compressor **120** of the high pressure stage turbocharger **108** is provided downstream thereof. An intercooler **121** that cools intake air turbocharged by the low pressure stage turbocharger **110** and the high pressure stage turbocharger **108** is provided downstream of the compressor **120**, and an intake throttle **122** that limits an intake air amount in accordance with an instructed intake throttle opening is provided downstream thereof. Downstream of the intake throttle **122**, the intake pipe **117** is connected to the intake manifold **104**.

Next, the configuration of the fuel injection system will be described. A piston head **132** is configured to stroke through a cylinder **131**, which is shown by cutting away a part of the engine **101**. An injector **133** for injecting fuel is attached to the cylinder **131**, and an injection port of the injector **133** is disposed above a top dead center position of the piston head **132**. Although shown in a simplified form in the drawing, the engine **101** includes a plurality of cylinders **131**, and the injector **133** is provided in each cylinder **131**. High pressure fuel is supplied to each injector **133** from a common rail **134**. Although not shown in detail in the drawing, the injector **133** includes a valve body driven by electromagnetic force from a coil, and the injection port is opened in accordance with a duration (an energization time) of a pulse current for energizing the coil.

A high pressure fuel pipe **136** that supplies fuel at a high pressure (a common rail fuel pressure) from a high pressure pump **135** is connected to the common rail **134**. An intermediate pressure fuel pipe **138** that supplies fuel at an intermediate pressure (an exhaust pipe injection fuel pressure), which is higher than atmospheric pressure but lower than the common rail fuel pressure, from a feed pump **137** is connected to



the high pressure pump **135**. The feed pump **137** takes in fuel from an atmospheric pressure fuel tank **139** via a low pressure fuel pipe **140**. The feed pump **137** is coupled to a crankshaft, not shown in the drawing, and rotated in accordance with the engine **101** so as to pump fuel at a pumping force corresponding to an engine rotation speed. The feed pump **137** is thus capable of supplying fuel at an exhaust pipe injection fuel pressure corresponding to the engine rotation speed to the intermediate pressure fuel pipe **138**.

In the present invention, an exhaust pipe injector **141** for injecting fuel into the exhaust pipe **103** is provided downstream of the turbine **111** of the low pressure stage turbocharger **110** and upstream of the exhaust brake valve **112**. Fuel from the feed pump **137** is supplied to the exhaust pipe injector **141** via the intermediate pressure fuel pipe **138**.

A recovery fuel pipe **142** that recovers surplus fuel in the fuel tank **139** is connected respectively to the high pressure pump **135**, the common rail **134**, and the injector **133**.

Next, various sensors will be described.

A water temperature sensor **151** that detects a cooling water temperature, a crank angle sensor **152** that detects an index on the crankshaft, not shown in the drawing, as a crank angle reference position, an oil level sensor **153** that detects a remaining amount of engine oil, and so on are provided in the engine **101**. An engine exhaust gas temperature sensor **154** is provided in the exhaust manifold **102**. A boost pressure sensor **155** is provided in the intake manifold **104**.

A DOC inlet exhaust gas temperature sensor **156** that detects an exhaust gas temperature at an inlet of the DOC **114**, a DPF inlet exhaust gas temperature sensor **157** that detects the exhaust gas temperature at an inlet of the DPF **115**, and a differential pressure sensor **158** that detects a differential pressure, which is a pressure difference in the exhaust gas between the inlet and an outlet of the DPF **115**, are provided in the DPF unit **113**. When PM accumulates in the DPF **115**, the differential pressure increases in accordance with the increase in the accumulation amount, and therefore a DPF regeneration timing can be determined on the basis of the differential pressure. A temperature of the DPF **115** during DPF regeneration and so on can be confirmed from the DPF inlet exhaust gas temperature detected by the DPF inlet exhaust gas temperature sensor **157**.

An exhaust pipe injection fuel pressure sensor **159** that detects the exhaust pipe injection fuel pressure, which is a fuel pressure applied to the exhaust pipe injector **141**, is provided in the intermediate pressure fuel pipe **138**. A fuel temperature sensor **160** that detects a fuel temperature is provided at an inlet of the high pressure pump **135**. A common rail fuel pressure sensor **161** that detects the common rail fuel pressure, which is a fuel pressure applied to the injector **133** of each cylinder **131**, is provided in the common rail **134**. An air flow sensor (a MAF sensor) **162** that detects a flow rate of the air suctioned into the intake pipe **117** is provided in the intake pipe **117** downstream of the air cleaner **118**.

A high pressure stage turbo rotation speed sensor (not shown) that detects a rotation speed of a shaft that connects the turbine **109** to the compressor **120** is provided in the high pressure stage turbocharger **108**.

Various other conventional sensors not illustrated in the drawing are provided in the engine **101**, the intake/exhaust system, and the fuel injection system.

Next, a configuration of a control system will be described.

The high pressure stage turbocharger **108** is a variable nozzle turbocharger (VNT, also known as a variable geometry turbo VGT and a variable geometry system VGS) that performs turbocharging when the turbine **109** disposed in the exhaust pipe **103** and the compressor **120** disposed in the

intake pipe **117** are coupled by the shaft so as to rotate integrally. At this time, a turbocharging amount of the high pressure stage turbocharger **108** can be adjusted using an actuator. More specifically, a nozzle actuator **164** for adjusting an opening area of the turbine **109** is provided upstream of the turbine **109**. A turbo controller **165** controls the turbocharging amount or a turbocharging pressure by driving the nozzle actuator **164** while referencing the rotation speed of the shaft, which is detected by the high pressure stage turbo rotation speed sensor **163**.

Means for controlling various parts of a vehicle, including fuel injection into the engine **101**, are incorporated into an electronic control unit (ECU) **171** in the form of a program. The ECU **171** performs control such as fuel injection control by detecting the engine rotation speed, an accelerator opening, a load torque, an air amount, and so on at all times as engine parameters representing an engine condition. To obtain propulsive force in the engine **101**, the ECU **171** performs multi-injection control, in which fuel injection is performed a plurality of times within a single combustion cycle of each cylinder **131** from the injector **133** at an appropriate crank angle. The multi-injection control is used to raise the exhaust gas temperature.

The ECU **171** is provided with an exhaust pipe injection regeneration control unit **172** that performs DPF regeneration by controlling an exhaust pipe injection, and a regeneration deceleration period intake/exhaust control unit **173** which, when the vehicle is decelerated by the engine brake during DPF regeneration by means of an exhaust pipe injection, increases an exhaust gas flow rate through the exhaust pipe **103** by fully closing the opening of the EGR device **123**, fully opening the opening of the intake throttle **122**, and increasing the turbocharging amount of the high pressure stage turbocharger **108**.

DPF regeneration is performed by the ECU **171** every time a traveled distance of the vehicle reaches a predetermined distance and when the differential pressure detected by the differential pressure sensor **158** reaches or exceeds a predetermined value.

An operation of the exhaust gas purification system according to the present invention will now be described.

The ECU **171** starts DPF regeneration when the traveled distance of the vehicle reaches the predetermined distance or when the differential pressure detected by the differential pressure sensor **158** reaches or exceeds the predetermined value.

More specifically, when the exhaust gas temperature at the inlet of the DOC **114**, detected by the DOC inlet exhaust gas temperature sensor **156**, is lower than an activation temperature of the DOC **114**, the ECU **171** increases the exhaust gas temperature to the activation temperature of the DOC **114** by increasing the amount of fuel injected in the multi-injection control.

When the exhaust gas temperature detected by the DOC inlet exhaust gas temperature sensor **156** reaches the activation temperature of the DOC **114**, the exhaust pipe injection regeneration control unit **172** controls the exhaust pipe injection. More specifically, the exhaust pipe injection regeneration control unit **172** increases the amount of fuel injected through the exhaust pipe injector **141** when the exhaust gas temperature at the inlet of the DPF **115**, detected by the DPF inlet exhaust gas temperature sensor **157**, is lower than the incineration temperature of the PM, and reduces the amount of fuel injected through the exhaust pipe injector **141** when the exhaust gas temperature at the inlet of the DPF **115** is sufficiently higher than the incineration temperature of the PM. In so doing, the temperature of the DPF **115** is main-



tained at the incineration temperature of the PM, and as a result, the DPF 115 is regenerated.

It is assumed that, at this time, the accelerator pedal is released such that the engine brake is activated. Hence, the vehicle is decelerated by the engine brake during DPF regeneration by means of the exhaust pipe injection, and therefore the regeneration deceleration period intake/exhaust control unit 173 increases the exhaust gas flow rate through the exhaust pipe 103 by fully closing the opening of the EGR device 123, fully opening the opening of the intake throttle 122, and increasing the turbocharging amount of the high pressure stage turbocharger 108 above a current level. More specifically, when the EGR valve 107 of the EGR device 123 is fully closed, exhaust gas is no longer recirculated from the exhaust manifold 102 to the intake manifold 104, and therefore all of the exhaust gas from the engine 101 flows downstream through the exhaust pipe 103. Further, when the opening of the intake throttle 122 is fully opened, all of the fresh air turbocharged by the compressor 120 of the high pressure stage turbocharger 108 is supplied to the engine 101. Furthermore, when the turbocharging amount of the high pressure stage turbocharger 108 is increased beyond the current level, the amount of fresh air supplied to the engine 101 increases further. As a result, the exhaust gas flow rate through the exhaust pipe 103 can be increased beyond a current level while taking DPF regeneration into consideration.

The present inventors ascertained that when exhaust gas is retained in the exhaust pipe 103, the fuel from the exhaust pipe injector 141 is ignited in the exhaust pipe 103, leading to an increase in the respective temperatures of the DPF 115 and the DOC 114, but found that when the exhaust gas flow rate is increased, the fuel is not ignited in the exhaust pipe 103. Therefore, when the exhaust gas flow rate through the exhaust pipe 103 is increased by the control of the regeneration deceleration period intake/exhaust control unit 173, as described above, the fuel from the exhaust pipe injector 141 is prevented from being ignited in the exhaust pipe 103. As a result, the exhaust pipe injection can be continued.

Hence, according to the present invention, when the vehicle is decelerated by the engine brake during DPF regeneration by means of the exhaust pipe injection, the exhaust gas flow rate through the exhaust pipe 103 is basically increased. During engine braking, the temperature of the exhaust gas discharged from the engine 101 is low, and therefore, when the exhaust gas flow rate is increased, the temperature of the DOC 114 is likely to decrease correspondingly. By controlling the turbocharging amount of the high pressure stage turbocharger 108 to a predetermined value so that the turbocharging amount is not increased excessively, however, an early reduction in the temperature of the DOC 114 is prevented.

When the engine braking continues for a long time, the DOC 114 is cooled by the exhaust gas so as to fall below the activation temperature. To prevent white smoke generation at this time, the exhaust pipe injection is stopped and the temperature maintaining mode described above is set. Hence, according to the present invention, the exhaust pipe injection is continued only during a period where the temperature of the DOC 114 is maintained at the activation temperature. For example, when the accelerator pedal is released such that the engine brake is activated following vehicle travel in which the engine 101 is operated at full load, it is known that the temperature of the DOC 114 remains at the activation temperature for a while (approximately 30 seconds, for example, although the period differs depending on the vehicle type) following the start of the engine brake operation. Hence, the exhaust pipe injection can be continued while the temperature

of the DOC 114 remains at the activation temperature. Note that a full load operation is an operation in which an accelerator opening is large, the engine rotation speed is high, and an output torque is large.

Therefore, in a case where, for example, DPF regeneration by means of an exhaust pipe injection is started while the vehicle accelerates on an expressway, travels uphill, or the like, and in this condition, the vehicle comes to a downhill slope or draws near to a preceding vehicle such that the accelerator pedal is released and engine braking starts, the DPF regeneration is continued.

As described above, with the exhaust gas purification system according to the present invention, when the vehicle is decelerated by the engine brake during DPF regeneration by means of an exhaust pipe injection, the exhaust gas flow rate through the exhaust pipe 103 is increased by fully closing the opening of the EGR device 123, fully opening the opening of the intake throttle 122, and increasing the turbocharging amount of the high pressure stage turbocharger 108. As a result, fuel ignition in the exhaust pipe 103 can be prevented, and the DPF regeneration can be continued.

Note that in this embodiment, only a case in which the engine brake is activated was described, but the accelerator pedal is also released during a foot brake operation, and therefore the present invention can also be applied to this case. During use of an exhaust brake, however, the exhaust pipe injector 141 is shut off from the DPF unit 113 by the exhaust brake valve 112, and therefore the exhaust pipe injection is not performed to prevent an exhaust pressure from becoming excessive.

The invention claimed is:

1. An exhaust gas purification system for a vehicle engine, comprising:

- a diesel particulate filter disposed in an exhaust pipe of the engine to collect particulate matter;
- an oxidation catalyst disposed in the exhaust pipe upstream of the diesel particulate filter;
- an exhaust gas recirculation device that recirculates exhaust gas from an exhaust manifold to an intake manifold of the engine via an amount of opening of the exhaust gas recirculation device;
- a turbocharger, a turbocharging amount of which is adjusted using an actuator;
- an intake throttle disposed between the turbocharger and the intake manifold to limit an intake air amount in accordance with an instructed intake throttle opening; and
- a regeneration deceleration period intake/exhaust controller that, when the vehicle decelerates during regeneration of the diesel particulate filter, but is still moving, is configured to increase an exhaust gas flow rate through the exhaust pipe by controlling the amount of opening of the exhaust gas recirculation device and an amount of opening of the intake throttle and adjusting the turbocharging amount, and when a temperature of the oxidation catalyst falls below a temperature necessary to activate regeneration, is configured to set a temperature maintaining mode in which the amount of opening of the exhaust gas recirculation device is increased.

2. The exhaust gas purification system according to claim 1, wherein when the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit fully closes of the exhaust gas recirculation device.

3. The exhaust gas purification system according to claim 1, wherein when the vehicle decelerates during regeneration



9

of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit fully opens the intake throttle.

4. The exhaust gas purification system according to claim 2, wherein when the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit fully opens the intake throttle.

5. The exhaust gas purification system according to claim 1, wherein when the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit increases the turbocharging amount.

6. The exhaust gas purification system according to claim 2, wherein when the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit increases the turbocharging amount.

7. The exhaust gas purification system according to claim 3, wherein when the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit increases the turbocharging amount.

8. The exhaust gas purification system according to claim 4, wherein when the vehicle decelerates during regeneration of the diesel particulate filter, the regeneration deceleration period intake/exhaust control unit increases the turbocharging amount.

9. The exhaust gas purification system according to claim 1, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

10. The exhaust gas purification system according to claim 2, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

11. The exhaust gas purification system according to claim 3, further comprising:

10

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

12. The exhaust gas purification system according to claim 4, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

13. The exhaust gas purification system according to claim 5, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

14. The exhaust gas purification system according to claim 6, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

15. The exhaust gas purification system according to claim 7, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

16. The exhaust gas purification system according to claim 8, further comprising:

an exhaust pipe injector that is disposed upstream of the diesel particulate filter in order to inject fuel into the exhaust pipe; and

an exhaust pipe injection regeneration control unit that regenerates the diesel particulate filter by controlling fuel injection from the exhaust pipe injector.

\* \* \* \* \*